

WHAT IS CLAIMED IS

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1. A plastic optical element producing method  
for producing a plastic optical element by an ejection  
molding which uses a mold having a cavity of a  
predetermined volume and at least one transfer surface  
10 formed in a cavity surface which defines the cavity,  
injects a melted resin material into the mold and  
transfers the transfer surface which forms an optical  
surface of the plastic optical element by a resin  
pressure generated within the cavity, and removes the  
15 plastic optical element from the mold to be naturally  
cooled, comprising the step of:

(a) cooling the optical surface of the plastic  
optical element with priority in a state where a  
temperature of the plastic optical element is within a  
20 predetermined temperature range which is less than or  
equal to a glass transition temperature of the resin  
material.

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2. The plastic optical element producing method as claimed in claim 1, further comprising the step of:

(b) annealing at least a portion of a surface of the plastic optical element other than the optical surface.

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3. The plastic optical element producing method as claimed in claim 1, further comprising the step of:

(b) annealing at least a portion of a surface of the plastic optical element other than the optical surface via a temperature control member.

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4. The plastic optical element producing method as claimed in claim 3, wherein said step (b) arranges a plurality of plastic optical elements side by side by contacting respective surfaces other than the optical surface, and contacts a surface other than the

optical surface of each plastic optical element arranged at an outermost position to the temperature control member.

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5. The plastic optical element producing method as claimed in claim 3, wherein said step (b) uses  
10 a temperature control member having heating means.

15 6. The plastic optical element producing method as claimed in claim 5, wherein said step (b) uses a non-contacting heating apparatus as the heating means.

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7. The plastic optical element producing method as claimed in claim 6, wherein said step (b) uses an infrared ray heating apparatus or a high-frequency  
25 heating apparatus as the non-contacting heating

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apparatus.

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8. The plastic optical element producing method as claimed in claim 1, wherein said step (a) cools the optical surface of the plastic optical element.

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9. The plastic optical element producing method as claimed in claim 1, further comprising the step of:

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(b) annealing the optical surface of the plastic optical element via a temperature control member.

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10. The plastic optical element producing method as claimed in claim 9, further comprising the step of:

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(c) controlling a temperature of the temperature

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control member depending on a surrounding temperature.

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11. The plastic optical element producing method as claimed in claim 3, further comprising the step of:

(c) controlling a temperature of the temperature control member depending on a surrounding temperature.

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12. The plastic optical element producing method as claimed in claim 2, wherein said step (b) carries out an annealing at a rate of 3°C per minute or less.

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13. The plastic optical element producing method as claimed in claim 1, wherein a lower limit value of the predetermined temperature range is [GTT -

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40°C], where GTT denotes a glass transition temperature of the resin material.

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14. The plastic optical element producing method as claimed in claim 1, further comprising the step of:

10 (b) heating the plastic optical element which has a temperature lower the predetermined temperature range up to a temperature within the predetermined temperature range before carrying out an annealing with respect to the plastic optical element.

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15. The plastic optical element producing method as claimed in claim 14, wherein said step (b) maintains the temperature of the plastic optical element within the predetermined temperature range until the annealing is started.

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16. The plastic optical element producing method as claimed in claim 1, further comprising the step of:

(b) cooling the plastic optical element which has  
5 a temperature higher the predetermined temperature range down to a temperature within the predetermined temperature range before carrying out an annealing with respect to the plastic optical element.

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17. The plastic optical element producing method as claimed in claim 16, wherein said step (b)  
15 maintains the temperature of the plastic optical element within the predetermined temperature range until the annealing is started.

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18. A plastic optical element producing apparatus for producing a plastic optical element by an ejection molding which uses a mold having a cavity of a  
25 predetermined volume and at least one transfer surface

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formed in a cavity surface which defines the cavity,  
injects a melted resin material into the mold and  
transfers the transfer surface which forms an optical  
surface of the plastic optical element by a resin  
5 pressure generated within the cavity, and removes the  
plastic optical element from the mold to be naturally  
cooled, comprising:

at least one temperature control member contacting  
at least a portion of a surface of the plastic optical  
10 element other than the optical surface to carry out an  
annealing with respect to the plastic optical element  
during a resin cooling process when a temperature of the  
plastic optical element falls within a predetermined  
temperature range lower than or equal to a glass  
15 transition temperature of the resin material.

20 19. The plastic optical element producing  
apparatus as claimed in claim 18, comprising a pair of  
temperature control members, wherein a plurality of  
plastic optical elements are arranged side by side by  
contacting respective surfaces other than the optical  
25 surface, and each of the pair of temperature control

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members contacts a surface other than the optical  
surface of a corresponding one of the plastic optical  
elements arranged at an outermost position so that the  
plurality of plastic optical elements are sandwiched  
5 between the pair of temperature control members.

10 20. The plastic optical element producing  
apparatus as claimed in claim 18, wherein said  
temperature control member includes heating means.

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21. The plastic optical element producing  
apparatus as claimed in claim 20, wherein said heating  
means includes a non-contacting heating apparatus.

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22. The plastic optical element producing  
25 apparatus as claimed in claim 21, wherein said non-

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contacting heating apparatus includes an infrared ray heating apparatus or a high-frequency heating apparatus.

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23. A plastic optical element producing apparatus for producing a plastic optical element by an ejection molding which uses a mold having a cavity of a predetermined volume and at least one transfer surface formed in a cavity surface which defines the cavity, injects a melted resin material into the mold and transfers the transfer surface which forms an optical surface of the plastic optical element by a resin pressure generated within the cavity, and removes the plastic optical element from the mold to be naturally cooled, comprising:

at least one temperature control member contacting and cooling the optical surface of the plastic optical element during a resin cooling process when a temperature of the plastic optical element falls within a predetermined temperature range lower than or equal to a glass transition temperature of the resin material.

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24. The plastic optical element producing  
apparatus as claimed in claim 18, wherein said  
temperature control member controls the temperature of  
the plastic optical element depending on a surrounding  
5 temperature.

10 25. The plastic optical element producing  
apparatus as claimed in claim 23, wherein said  
temperature control member controls the temperature of  
the plastic optical element depending on a surrounding  
temperature.

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26. The plastic optical element producing  
20 apparatus as claimed in claim 18, further comprising:  
means for annealing at least the portion of the  
surface of the plastic optical element other than the  
optical surface at a rate of 3°C per minute or less.

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27. The plastic optical element producing apparatus as claimed in claim 23, further comprising:

means for annealing at least a portion of a surface of the plastic optical element other than the optical surface at a rate of 3°C per minute or less.

28. The plastic optical element producing apparatus as claimed in claim 18, comprising a plurality of temperature control members, wherein each of the plurality of temperature control members is used for an annealing until the annealing is completed within one cycle of the resin cooling process.

29. The plastic optical element producing apparatus as claimed in claim 18, wherein a lower limit value of the predetermined temperature range is [GTT - 40°C], where GTT denotes a glass transition temperature of the resin material.

30. The plastic optical element producing apparatus as claimed in claim 23, wherein a lower limit value of the predetermined temperature range is [GTT - 40°C], where GTT denotes a glass transition temperature of the resin material.

10 31. The plastic optical element producing apparatus as claimed in claim 18, further comprising:  
means for heating the plastic optical element which has a temperature lower the predetermined temperature range up to a temperature within the predetermined  
15 temperature range before carrying out an annealing with respect to the plastic optical element.

20 32. The plastic optical element producing apparatus as claimed in claim 31, wherein said means maintains the temperature of the plastic optical element within the predetermined temperature range until the  
25 annealing is started.

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33. The plastic optical element producing apparatus as claimed in claim 18, further comprising:

means for cooling the plastic optical element which has a temperature higher the predetermined temperature range down to a temperature within the predetermined temperature range before carrying out an annealing with respect to the plastic optical element.

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34. The plastic optical element producing apparatus as claimed in claim 33, wherein said means maintains the temperature of the plastic optical element within the predetermined temperature range until the annealing is started.

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35. A plastic optical element which is produced by an ejection molding which uses a mold having a cavity of a predetermined volume and at least one transfer surface formed in a cavity surface which defines the cavity, injects a melted resin material into

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the mold and transfers the transfer surface which forms an optical surface of the plastic optical element by a resin pressure generated within the cavity, and removes the plastic optical element from the mold to be

5 naturally cooled, wherein:

the optical surface of the plastic optical element is cooled with priority during a resin cooling process in a state where a temperature of the plastic optical element is within a predetermined temperature range

10 which is less than or equal to a glass transition temperature of the resin material.

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36. A plastic optical element which is produced by an ejection molding which uses a mold having a cavity of a predetermined volume and at least one transfer surface formed in a cavity surface which

20 defines the cavity, injects a melted resin material into the mold and transfers the transfer surface which forms an optical surface of the plastic optical element by a resin pressure generated within the cavity, and removes the plastic optical element from the mold to be

25 naturally cooled, wherein:

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at least a portion of a surface of the plastic optical element other than the optical surface is contacted by at least one temperature control member to carry out an annealing with respect to the plastic optical element during a resin cooling process when a temperature of the plastic optical element falls within a predetermined temperature range lower than or equal to a glass transition temperature of the resin material.

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37. A plastic optical element comprising:  
an optical surface through which an incoming light  
is transmitted in a light transmitting direction; and  
a side surface,  
wherein a refractive index distribution is formed  
in the light transmitting direction.

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